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High Density Mixed Use as an Effective Scheme in Applying Sustainable Urban Design Principles in Amman, Jordan

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Abstract
The study seeks to explore the implementation of sustainable urban design principles in high density mixed use developments in Amman, Jordan. It was not known how HDMU mechanism would be implemented in Amman or what prerequisites were needed to enable this to happen. Accordingly, there was a need to research and propose an implementation framework. The primary research aim is to propose a framework, consisting of a set of recommendations for the implementation of SUDP using HDMU schemes using Amman as a case study. Using existing literature, this paper will review global sustainable urban indicators as it applies to the Amman context and highlight the constraints, solutions and the planning strategy to their delivery in HDMU in selected cases. The study uses two approaches, the testing-out and exploratory approaches, adopting a mixed method approach by using comparative cases, interviews and a questionnaire survey. Context-derived data and statistics analysed together were used to explore the components of this framework. The questionnaire was also used to evaluate core findings of the research. The research's contribution lies in devising an implementation framework which consists of a series of practical recommendations for implementing HDMU schemes and to inform the future development of the Amman.
Keywords: High density mixed use (HDMU), Sustainable urban design principles (SUDP), Amman city, Urban sustainability indicators and implementation framework

1. Introduction

The research examines the role of sustainable urban design principles in delivering sustainable high density mixed use schemes in Amman, Jordan. This research selected the city of Amman to apply of sustainable urban design principles, using their indicators. There is a clear need to undertake this kind of research in Amman which remains, in academic literature, a little studied city (Hanania, 2014). In 1921, the city was named the capital of Jordan. It is a bustling and growing city that has tended to blend its rich natural and cultural heritage with modern urban development (Potter *et al.,* 2009; Abu-Dayyeh, 2004b; Al Rawashdeh and Saleh, 2006). In recent years, and especially since the early 1990s, the city has witnessed exponential growth doubling in size as a result of influxes of nationals from neighbouring states following the 1991 Iraqi invasion of Kuwait and the subsequent war, the 2003 second Gulf War, and more recently as a result of the war in Syria. This rapid growth has evidently led to a set of problems which affected the urban form for the city and its ability to deliver services effectively to its growing residents. Transportation infrastructure, access to power and water access suffered as a result. Urban sprawl, a well-established phenomenon, was allowed to take hold even more. As a result, it has therefore become necessary to propose and implement a framework that addresses the issues arising while taking advantage of the opportunity to integrate sustainable development solutions to guide future growth and development. Therefore, this research tried to explore the main components that can constitute a successful and effective implementation framework for the HDMU schemes in the allocated areas in the master plan drawing broader lessons from elsewhere and reflecting on these where needed.

2. Literature review

This research builds on previous work for the development of the 2010 Amman Master Plan proposing, a first for the city, sustainable high density mixed use (HDMU) development in three distinct geographical areas in the city. High density mixed use developments conceived as part of master planned areas in a new one area of activity for Amman and for Jordan. At the commencement of this research, it was not known how HDMU mechanisms would be implemented in the Amman context or what prerequisites were needed to enable this to happen. Accordingly, there was a need to research and identify an implementation framework. The output framework was achieved through defining the main components which represent suitable indicators, constraints, solutions and planning strategies.

The underpinning literature review comprised, amongst others, works by Pearce (2000), Pearce and Barbier (2000), DEA (2010,2006,2005,1998), Ndeke (2011), Lehman (2010) and Al Waer et al. (2014) found plenty of frameworks for assessing urban sustainability. In particular, Al Waer et al. (2014, p. 8) noted how sustainable communities need to be developed within an ''inclusive framework''. From the literature, it was found that the components of this framework could include all or any of the following: (1) providing a broad variety of indicators using their measurements; (2) identifying the consequences of actions such as constraints and

solutions, and; (3) identifying pathways through a planning strategy for managing the process path to a 'desired future' (Pearce and Barbier, 2000; DEA, 2010,2006,2005,1998; Ndeke, 2011; Al Waer *et al.,* 2014 and Lehmann, 2010). This study identified the components constituting the implementation framework to providing the guidelines which can be used effectively in the context of Amman.

Starting from here, the research raises the key question of how the sustainable urban design principles can be implemented in HDMU schemes within the context of Amman, Jordan. Therefore, the research aims to propose a framework, consisting of a set of recommendations providing guidelines for the implementation of sustainable urban design principles using HDMU schemes using Amman as a case study. The additional output is to inform the future development of the city's master plan. Accordingly, the contribution to knowledge of this thesis lies in a series of multi-faceted recommendations constituting an implementation framework providing guidelines for implementing HDMU schemes, in order to inform the future development of the master plan. In addition to the contribution to knowledge, it is anticipated that the outputs will also address the planning and implementation gaps for the Amman master plan. Therefore, the literature has identified the most important issues for achieving that as follows:

2.1 SUSTAINABLE URBAN DESIGN PRINCIPLES AND INDICATORS

For the purpose of this research, these principles are defined as principles that can achieve sustainable urban design goals on three levels: spatial, content and procedures covering a range of social, environmental, economic and governance issues (McGeough *et al.,* 2004; CSD, UN, 2007; Lehmann, 2010; Daseking *et al.*, 2010). The Freiburg Charter for Sustainable Urbanism (2010) classified these principles into 12 principles are represented in; (1) spatial principles include City of Diversity, Safety and Tolerance, City of Neighbourhoods, City of Short Distance and Urban Development along Public Transportation Lines; (2) Content Principles include Education, Science and Culture, Commerce, Economy and Employment, Nature and Environment and Quality of Design; and (3) Principles of procedure include Long-term Vision, Communication and Participation, Reliability, Obligation and Fairness and Cooperation, Participation and Partnership (Daseking *et al.*, 2010). Moreover, this research identified that the implementation of these principles needs to determine and implement relevant urban sustainability indicators at the right scale (Al waer, et al., 2013).

Therefore, this research outlined the indicators which was measured for implementing of sustainable urban design principles in HDMU schemes. It identified a broad variety of indicators to help to determine how successful the guidelines in the implementation and management of sustainable urban design principles using high density mixed use. Hence, these indicators were applied in the context of Amman within three case study areas are; A central parkway, B southern gateway, C northern gateway. In order to achieve the stated aims of the thesis, the review of the literature on indicators highlights several international urban sustainability indicators CSD, UN, (2007a); Shen *et al.,* (2011), the Council of the European Union Sustainable Development Strategy (European Commission, Eurostat, 2009a), BREEAM Communities (2012), LEED ND (2009;2011), ESTIDAMA (2010), GORD/GSAS ND (2014) and Green Star (2012), SuBE Tool, sustainability Checklist for Regional Shopping Centres (SCRSC) (2006) and other scientific papers and authors like Serge Salat, (2012).

For the purpose of this study, the Sustainability Checklist for Regional Shopping Centres (SCRSC) model, the forerunner to SuBET, as shown in Table 2.3 was adopted to be applied at the neighbourhood level using three case study areas previously identified in the City of Amman's 2010 Master Plan. The underlying rationale for this choice was that these areas in the master plan contain outline proposals for shopping centres within high density mixed use schemes where the regional nature of the shopping provision was the most dominant. Therefore, the regional shopping centres model is used instead of SuBET, because the SCRSC specifically contains the indicators focusing commercial issues. The creators of the SCRSC, Al Waer and Sibley, had already documented its flexibility for application at different phases of the life cycle of buildings. This can be used before, during or after the completion of the design of a project (AlWaer and Sibley, 2006).

Additionally, this model was selected because it includes a broad variety of indicators related to urban environment, architectural typology, community facilities and urban form linked to broader regional, global and national scales. This helped to address the relationship between sustainable urban design at the local level and high density mixed use centres by investigating their impacts on the social, environmental and economic conditions as outlined by AlWaer and Sibley (2006). SCRSC was also developed based on the economic, social, and environmental issues related to the buildings, which include land use, water, materials, energy, indoor environmental quality. This achieves a balance for the requirements of environmental, social and economic factors.

On the governance dimension, AlWaer et al. (2014) noted how the public authority, private sectors and local community are the key drivers for creating sustainable communities. In addition, Miller and Floricel (2000) pointed out that the governance dimension must take into account private partnership and public institutional frameworks that consider community consent. Therefore, the research added a set of common governance indicators between the United Nation's and the European Union to the SCRSC model which considers the

forerunner to SuBETool, as shown in Appendix 1. Accordingly, the research will identify the indicators that can be tested at the neighbourhood level in Amman.

2.2 CASE STUDY AREAS (AMMAN, JORDAN AND CURITIBA, BRAZIL)

This thesis selected the city of Amman to apply sustainable urban design principles, using urban sustainability indicators. The researcher is an academic from a Jordanian university and Amman is a city in which he has lived and worked and with which he is, therefore, quite familiar.

There is a clear need to undertake this kind of research in Amman which remains, in academic literature, a little studied city (Hanania, 2014). In 1921, the city was named the capital of Jordan. It is a bustling and growing city that has tended to blend its rich natural and cultural heritage with modern urban development (Potter *et al.,* 2009; Abu-Dayyeh, 2004a; Al Rawashdeh and Saleh, 2006). In recent years, and especially since the early 1990s, the city has witnessed exponential growth doubling in size as a result of influxes of nationals from neighbouring states following the 1991 Iraqi invasion of Kuwait and the subsequent war, the 2003 second Gulf War, and more recently as a result of the war in Syria.

The consequences of these geopolitical upsets are, amongst others, challenges to the urban form for the city. These include pressures on the transport infrastructure, access to power and water, access to natural gas, and sprawl driven by socio-economic pressures. It became necessary at the start of the 21st century to propose and implement a master plan that addresses these issues while taking advantage of the opportunity to integrate sustainable development solutions to guide future growth and development. The vision that was put together proposed densification of areas in the city which conforms to sustainable urban design principles. The principles were used to integrate ecologically sensitive urban design guidelines, culture and heritage promotion, green city principles, effective governance and service delivery, and public spaces and social inclusion (GAM, 2010; Potter *et al.,* 2009).

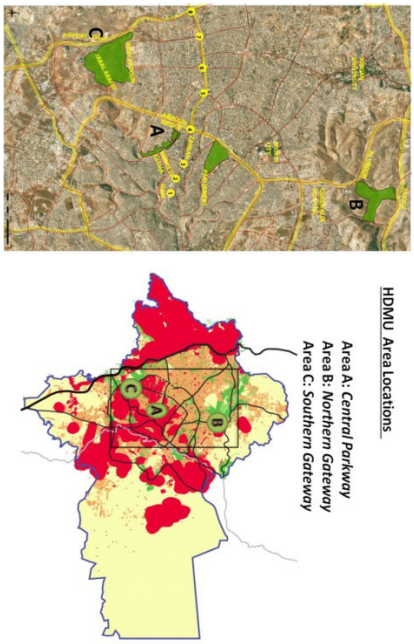

Figure 1: HDMU area locations, (Sources: GAM, 2007). Modified by the researcher

Figure. 1 shows a schematic plan of the city of Amman which indicates the geographical case study areas in Amman used for the purposes of this research as A, B and C. These areas, proposed as densification corridors in the city's 2010 Master Plan, provide an opportunity to apply and test urban sustainability indicators as part of the research undertaken for this doctoral study.

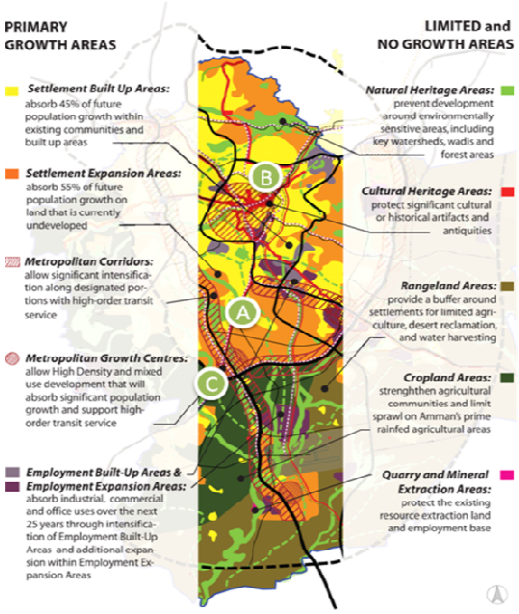

Figure 2: Metropolitan growth plan 2025; Area distributions, (Sources: GAM, 2007). Modified by the researcher

Figure. 2 shows the rationale behind selecting the three case study areas outlined above. The 2010 Amman Master Plan designated these three areas as Primary Growth Areas where good 'sustainable' planning and development principles can co-exist in harmony with sustainable high-density urban design (GAM, 2010).

For the purpose of this thesis and research into high density mixed use, the primary reasons for selecting the three areas are outlined here. Area A in the centre was chosen because it offers the scope for significant intensification (new projects) and densification (of existing areas) close to areas that have seen recent growth and expansion. Area B was selected because it could accommodate high density mixed use without impacting on heritage areas in the older parts of the city. Area C was selected because it proposes high density projects in new growth areas in the southern part of the city along the airport corridor. All three therefore, in addition to being selected by the city as growth areas (GAM, 2007), suit the research objectives set out in this thesis.

To commence the thesis, sustainable urban design solutions adopted elsewhere were explored. For example, Curitiba in Brazil which is similar to Amman as shown in Table 1 in terms of area, geography, climate, population growth, population density and temperature. In Curitiba, the sustainable urban design principles using high density mixed use schemes (HDMU) was also recently applied (Campbell, 2012). It also dealt with guidelines of sustainable urban design in terms of implementation and management (Campbell, 2012; Lerner, 1994). This accords with this research, which examines these guidelines in terms of implementation and management in Amman.

TABLE 1. The comparison between Amman and Curitiba

City	**Curitiba**	**Amman**
Location above sea level	914m above sea level	900 above sea level
Number of population	2.3 million	2.8 million
Area	430 km²	694 km2
Temperature	from 12ºC to 29ºC	from 13 to 34 °C
Climate	Temperate climate - seasonal fluctuations	Temperate climate
Location	Eastern Brazil	In the mid of Jordan at the West Asian
Population density	5348 h/ km²	4216 h/ km²

2.3 HIGH DENSITY MIXED USE (HDMU) WITHIN CASE STUDY AREAS IN AMMAN

The study uses the HDMU mechanism to implement sustainable urban design principles. The high density mixed use (HDMU) is used as the most suitable strategy to achieve sustainable urban principles in Amman, Jordan, because it accords with the topography, offers the lowest cost of infrastructure and architectural intensification for the areas, and efficiently utilizes the already limited land supply (GAM, 2010; GAM, 2007; Leinberger, 2001; Smith, K. 2011; Lietz, et al. 2006; Zaman, et al. 2000). Moreover, This mechanism is more innovative than other ways such as; the compact city and the garden city, because HDMU encourages mixed use, and promotes urban activity in the city over a 24 hours period. It also ensures economic competitiveness and

facilitates infrastructural development (Lau and Gonzalez, 2012; Jenks and Dempsey, 2005; Coupland, 1997). In addition, on more global scales the HDMU works in several American and Asian examples among others. This follows on from the works of people like Jenks and Williams advocating an approach towards a compact city (Masnavi, 2000).

Jenks and Burgess, (2000), Williams (1999) and Van der Waals (2000) state that the compact city respects the environmental criteria (except for urban air quality and urban heat). Moreover, it includes public transport system insufficient to face the traffic effect of increasing population density, because traffic volumes and congestion increase rapidly. in spite of reduction of car use per capita, there is increase concentrations of motor traffic, it leads to worsening the local environment in those locations (Jenks and Burgess, 2000; Williams,1999). This causes social and environmental constraints, such as; limitations on car use, mixed land use, and residential uses (Westerink, et al., 2012). This leads to increasing its social costs and higher construction costs (Breheny, 1996; Striker, 2011). It has been applied in several cities, such as; Leipzig-Halle (Germany), Greater Manchester (UK), the Montpelier (France) and the Hage Region (Netherlands) (Striker, 2011). As for the garden city has a fragile transport system and social infrastructure. and also It does not offer employment opportunities for people (Bowie, 2013). Where there is few people may live within walking distance of their place of work (Gossop, 2006). It has been applied in several cities, such as; Letchworth and Welwyn Garden city (UK), Hellerau (Germany), Canberra (Australian), Mezaparks (Latvia) (Bowie, 2013).

Accordingly, the high density mixed use (HDMU) is used as the most suitable mechanism to achieve sustainable urban principles in Amman, Jordan, because it accords with the topography, presents the successful solutions with the lowest cost of infrastructure for the areas and efficiently use the limited land supply. In addition, there are three types of the high density mixed use represented in high rise with low coverage, low rise with high coverage and medium rise with medium coverage (Schwanke, 2003). Therefore, these types have distributed within three study areas in Amman.

In summary, the literature review highlighted the most important issues which relate to implementing sustainable urban design principles using HDMU schemes. Firstly, the principles of sustainable urban design, it identified that the implementation of these principles using (HDMU) needs to determine and implement relevant urban sustainability indicators. Secondly, the indicators which should be measured, they were applied in the context of Amman within three case study areas. Thirdly, the HDMU mechanism was used in this study to implement sustainable urban design principles.

3. Research methodology

The research tries to achieve the contribution to knowledge to fill the gap of knowledge. This gap represents in that there are no clear guidelines for implementing HDMU schemes in Amman. Therefore, these guidelines represent a set of gaps as identified by the literature review are; (1) identify a range of suitable indicators for the city of Amman; (2) identify the key constraints and solutions to overcome the challenges facing the implementation of sustainable urban design principles using HDMU schemes, and; (3) identify the planning strategy within which the schemes can be implemented and managed. Accordingly, this research addresses these gaps through turning these gaps into objectives. Therefore, the research has identified four objectives were devised around them and are as follows:

1. To identify and review urban sustainability indicators and measurements through a detailed literature review.
2. To identify a set of suitable indicators and constraints for the sustainable delivery of High Density Mixed Used Schemes through testing the indicators identified from the literature review. A suitable methodology was devised in order to achieve this.
3. To formulate the solutions and the planning strategy for the implementation of sustainable urban design principles using HDMU.
4. To propose the implementation framework through evaluating its components including the suitable indicators, constraints, solutions and planning strategy.

To achieve these objectives, the research has identified the suitable methods to provide the answers. Therefore, the four objectives have been distributed on the research methods, using the research design. The research uses two approaches to achieve the main objectives. Firstly, the testing-out approach tests the indicators which identified by the literature review, to identify the problems and issues related to sustainable urban design. This was achieved by using the model (SCRSC) which includes urban sustainability indicators. Secondly, the exploratory approach comes here to explore the unknown issues, such as; constraints, solutions and challenges. And then this study explored the suitable indicators for the city of Amman through using the comparative case study areas in Amman (A, B, C) and the questionnaire survey. Accordingly, this research depends on the mixed method (qualitative and quantitative method). The qualitative method was used by using comparative case study areas and interviews. The quantitative method was used by using questionnaire survey. Therefore, the research distributes the research objectives on the research methods identified as follows:

Objective 1: This objective was identified as a part of the literature review.
Objective 2: This was achieved by using testing model (SCRSC) which includes a broad variety of urban sustainability indicators and measurements within three case study areas in Amman master plan (A central parkway, B southern gateway, C northern gateway).
Objective 3: This was achieved by using questionnaire survey. The research uses this method to check the outcomes from comparative study areas such as; the suitable indicators, constraints and solutions for the city of Amman. In addition, this method identifies the planning strategy to mange this scheme in Amman. Therefore, the research used a wide range of professionals consist of architects and planners. These professionals are working for implementing the master plan either within public (Greater Amman Municipality) or private sector. For ensuring achieving the balance for the master plan, the research used two categories of professionals are architect and planners. The planners are responsible for creating the master plan while the architects are responsible for delivering the master plan.
Objective 4: This was achieved by using a set of interviews with professionals. It was used to evaluate the framework which consists of the research outcomes, which represent the guidelines for the implementation of sustainable urban design principles using HDMU in Amman.

4. Testing the urban sustainability indicators in Amman

The research tests these indicators by using their measurements, and then it compares the outcomes from testing model in three study areas in Amman such as; constraints. Thereafter, it uses the successful solutions used in the city of Curitiba to help to explore the solutions for the constraints to overcome the challenges facing the implementation of sustainable urban design principles using high density mixed use (HDMU).

The purpose of this section of the thesis is to test the three sets of indicators identified as part of the literature review at the neighbourhood level using their measurements, in the three case study areas in Amman. The first set is qualitative indicators which take into account the difficulties of interpreting judgment data. This type was tested by using a range of interviews. The second set is quantitative indicators which take into account numeric facts. This type was tested by using a range of numeric facts against the minimum measurable thresholds as specified by the UN Commission on Sustainable Development, which is responsible for sustainability in Jordan (CSD, UN 2007b; Shen *et al.,* 2011). The third set it mixed type indicators which depend on qualitative and quantitative approaches to test these indicators.

This research adopts a triangulation approach, drawing upon different sources of information in order to maximize the understanding of the research questions (Clifford and Valentine, 2003). This also ensured that rich and succinct data was collected. Evidence was obtained through the cooperation of the Greater Amman Municipality (GAM, 2010) as well as looking back through annual reports associated with the master plan for the city of Amman, covering the years 2002-2010. This was achieved by collaboration with the UN Commission on Sustainable Development (CSD) in Jordan, (2007b), the Department of Statistics in Jordan (DS, 2011) and the Royal Jordanian Geographical Centre (RJGC), Geographic Information System (GIS) services, (2012). The thesis used the data collected from these sources which ensured constancy and consistency which increases the reliability and validity of the research data.

In addition, a wide range of professionals comprising architects and planners were consulted to test the qualitative indicators. These professionals are sampled because they are involved in the implementation of the master plan either within Greater Amman Municipality or in the private sector, therefore those professionals are aware of the quality of process of performance of these schemes. This gave an opportunity to provide the necessary information regarding the implementation and management of the process of applying the principles of sustainable urban design on the master plan for the city of Amman. Planners were selected because they are responsible for creating the master plan, while the architects are responsible for delivering the master plan. These professionals were shortlisted from the classification of Jordan Engineers Association (JEA) and Greater Amman Municipality (GAM).

The interviews were recorded and transcribed by the researcher over a period of 60 days. One-to-one interviews typically lasted one hour in a setting chosen by the participants themselves in order to allow them to feel relaxed and at ease when talking to the researcher. The longest interview was 125 minutes and on average interviews were 60 minutes. Every participant signed a meeting information sheet and confidentiality form at the start of the interview. Field notes were made by the researcher before, during and after the interviews, and these were kept with interview notes to enable the researcher to reflect on issues and to offer a clear audit trail. This validity of data through credibility was at the core of the research findings.

Accordingly, the comparison was between the three selected areas (A, B, C), using the results of the application of urban sustainability indicators. The compliance analysis consists of three types of indicators. Firstly, the included indicators which have number of the achieved measurements more than have number of the not achieved measurements. Secondly, the not included indicators which have number of the not achieved measurements more than number of the achieved measurements. Thirdly, the similar indicators which have

equally number of the achieved measurements and number of the not achieved measurements (CSD, UN 2007b; Shen et al., 2011). Thereafter, the research took the existing data from testing model to be addressed in various figures for getting the percentages of indicators to each category.

5. Discussion on the comparison between the selected areas in Amman

This section presented a comparative study of the three case study areas in Amman, Jordan. The testing of the theoretical sustainable urban indicators in the context of the three case study areas in Amman is summarised in Table 2. This comparison uses the compliance analysis which consists of three types as represented by the included indicators (met threshold, denoted by *), the similar indicators (equals threshold, denoted by -, and the not included indicators (did not meet threshold, denoted by O).

Table 2: The comparison between the three selected areas (A, B, C) in Amman

Dimensions	***Indicators***	***Selected Areas***		
		A	***B***	***C***
Social	Functionality, Usability and Aesthetic aspects	*	*	*
	Indoor Environmental Quality/Health and Well being	---	---	---
	Architectural considerations and cultural heritage	*	*	*
	Local people facilities	*	O	O
	Customers facilities and trends	*	*	*
Environmental	Energy and Natural Resources	*	*	*
	Materials used, Durability and Waste	*	*	*
	Sustainable Land use and Site selection	*	O	O
	Transport and Accessibility	O	O	O
	Water and water conservation	*	*	*
Economic	Economic performance	*	*	*
	Employment of local people	O	O	O
	Management and Controllability	---	---	---
Governance	Public Participation	---	---	---
	Public Communication	*	O	*

•* met threshold (included) A: Central Parkway, B: Northern Gateway, C: Southern Gateway
•O did not meet threshold (not included)
•- equals threshold (similar)

Table. 2 shows the final results of testing the urban sustainability indicators within the selected areas (A, B, C), using high density mixed use (HDMU). These results transformed into numbers. Therefore, these results were highlighted and addressed in various figures to facilitate the comparative analysis between these areas. Hence, there was a compliance analysis for all of the 4 dimensions, and all of the 15 indicators.

5.1 DISCUSSION ON URBAN SUSTAINABILITY INDICATORS AT THE LEVEL OF MICRO SCALE

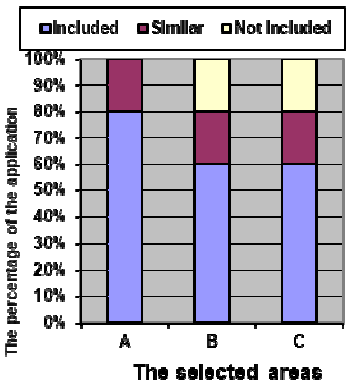

Figure 3 Social Indicators

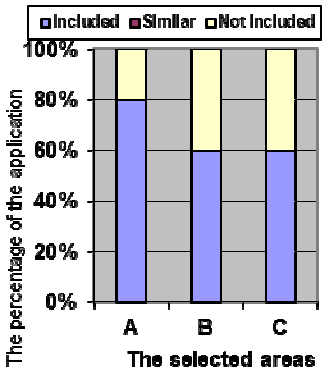

Figure 4 Environmental Indicators

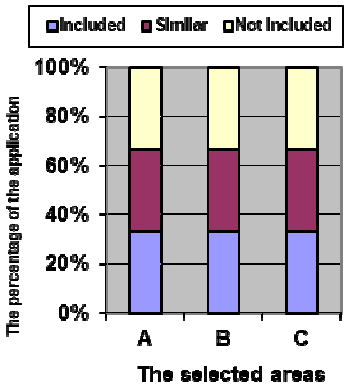

Figure 5 Economic Indicators

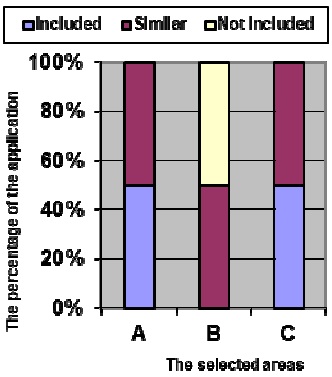

Figure 6 Governance Indicators

At the neighbourhood level of the selected areas (A, B, C), it was found that the social and environmental indicators were the most implemented within the proposed HDMU schemes (Figure 6.7 and 6.8).

Figure. 5 shows that economic indicators that were applied at the neighbourhood level of the selected areas (A, B, C), represent the lowest percentage of urban sustainability indicators, because the employment indicator at the local level was not considered and included in the proposed implementation of the HDMU schemes. However, efforts are being made to address the economic challenges in order to overcome constraints in the application of these indicators. This includes commercial sites within each of the case study areas aimed at creating more job opportunities for the population.

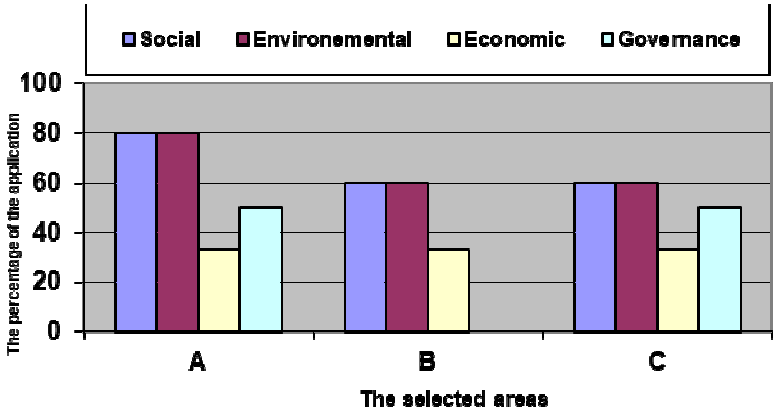

Figure 6: Compliance with the 4 dimensions

A priority was found for social and environmental indicators in the master plan (Figure. 6) of the city of Amman. It was also found that the high density mixed use have positively influenced the selected areas, through the increase of the percentage of environmental provisions. In addition, the social indicators implemented in the master plan have contributed to improvements to infrastructure for the selected areas which in turn positively serves the local community and investors.

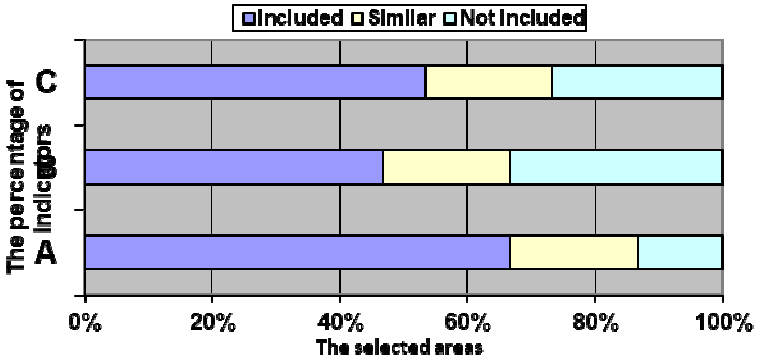

Figure 7: Compliance with the 15 indicators

Figure. 7 shows that the highest percentage (out of a total of 15) of urban sustainability indicators is within area A, where 10 are included and 3 are viable (similar). As for the lowest percentage of urban sustainability indicators, they are within area B, where 7 are included and 3 are viable (similar). Therefore, area B is considered the least favourable area to apply urban sustainability indicators using HDMU. This area contains the lowest possible number of indicators due to high land prices and its long distance from the city centre. Area A is identified as the most suitable for high density mixed used schemes and is, therefore, used in the next stages of this study. This area contains the largest possible number of indicators because of its close proximity to the city centre and the provision of the largest possible number of services.

According to the indicator tests identified by the literature review in Amman, the study identified the suitable indicators for the city based on the measurements which met the threshold as shown in Table 3 below. In the context of Amman, 10 indicators were determined for the city from the 15 indicators identified from Al-Waer and Sibley (2006). These indicators constituted the first component of the framework according to DEA (2010;2006;2005;1998), Ndeke (2011) and Lehman (2010). The 10 indicators were further checked at the questionnaire phase.

Table 3: Suitable indicators for the city of Amman

Dimensions	Indicators
Social	Functionality, Usability and Aesthetic aspects
	Local people facilities
	Architectural considerations and cultural heritage
	Customers facilities and trends
Environmental	Energy and Natural Resources
	Materials used, Durability and Waste
	Sustainable Land use and Site selection
	Water and water conservation (W)
Economic	Economic performance
Governance	Public Communication

Additionally, the thesis used the 'not achieved measurements' which did not meet the threshold for the indicators to identify the key constraints affecting the implementation of sustainable urban design principles using HDMU schemes in the Amman master plan, as shown in Table 4.

Table 4: Main constraints facing the implementation of the sustainable urban design principles in Amman

Indicators	Constraints
Social	The percentage of open space area compared to the city's area is low
	Indoor noise and acoustic noise in primary areas inside buildings
	Indoor air quality non monitoring inside buildings
	Shortage of internet facilities used as a way of online shopping
	The population income is inadequate for housing price or rent
Environmental	Difficulties in the management of water resources: inadequate of surface and ground water
	Absence of recycled materials in building construction
	Ineffective integration between land use, transport planning and other governance functions such as; ineffective infrastructure
	The percentage of open public green space compared to the city's area is low
	The percentage of waste treatment and disposal is low.
	Difficulties in moving around the city such as; traffic and congestion
	Absence of cycle lanes and cycle facilities
	Shortage of frequent fixed bus stops
Economic	The percentage of annual renewable energy consumption of total energy consumption is low
	Difficulties to create job and training opportunities for local community
Governance	Emergence of Local community resistance and negative media coverage for the master plan project, because of problems in communication between private sectors and local citizens and local government bodies.
	Difficulties in providing the skills and experience of professionals involved in delivering sustainable urban design.
	Unsuitability of the regulations and laws which govern land use

Table 4 extrapolates these constraints across the four dimensions for sustainable development: social, environmental, economic and governance. These constraints constitute the second component of the framework which was identified through the literature review by Pearce (2000) Pearce and Barbier (2000), DEA (2010;2006;2005;1998), Ndeke (2011), Lehman (2010) and Al Waer *et al.* (2014). These constraints were

further checked at the questionnaire phase. Additionally, the next phase of this study using a questionnaire survey further explored a set of solutions to overcome these constraints using the solutions applied in the city of Curitiba.

Finally, this research outlined part of the main components of the implementation framework represented in; (1) a set of the suitable indicators for the city of Amman through testing the indicators identified by the literature review; (2) a set of constraints which need to be addressed through finding their solutions and (3) a planning strategy, which constitute the other part of the main components of the implementation framework. These complexities will be addressed in detail in the next chapter through findings from the questionnaire survey and interviews for proposing the implementation framework.

In the questionnaire phase as part of the research, the questions focused on the issues which affect implementation such as suitable indicators, constraints and solutions to be used effectively as part of the framework for implementing SUDP using HDMU schemes in Amman. Starting from here, the study raised a set of key questions which it was judged would help to propose the implementation framework, as shown in Appendix 2. Appendix 2 also shows the main questionnaire responses.

6. Findings

From the questionnaire survey, the framework confirmed that all of the indicators identified by the testing model are suitable for the city of Amman. Moreover, the research confirmed that the ranking of the suitable urban sustainability indicators for the city of Amman which can be implemented by this process is (1) social (2) environmental (3) governance (4) economic. The survey responses confirmed 16 of the 18 constraints identified by testing the indicators, and it excluded 2 constraints. Also the survey responses provided a set of appropriate solutions to overcome the constraints. In addition, it identified a planning strategy including phases and requirements for the effective implementation of the framework.

The research identified an implementation framework of sustainable urban design principles. The framework consists of the three main components identified by the findings from the literature review: the suitable indicators, constraints and solutions/opportunities and a planning strategy for implementing this scheme in the context of Amman. The research examined these components to provide the guidelines that constitute the implementation framework and that can be used effectively in this context. The framework was created through testing the urban sustainability indicators in the context of Amman and thus informing the future development of the Amman Master Plan for its delivery according to sustainable urban design principles using HDMU schemes. The framework consists of the main findings. These findings were split into two parts: the first part includes two components of the main three components of this framework are; suitable indicators and constraints and solutions/opportunities for the city of Amman as shown in Figure. 8. The second part presents the third component of this framework, is the accompanying planning strategy comprising a set of phases and requirements for the effective implementation of HDMU schemes using sustainable urban design principles SUDP as shown in Figure. 9.

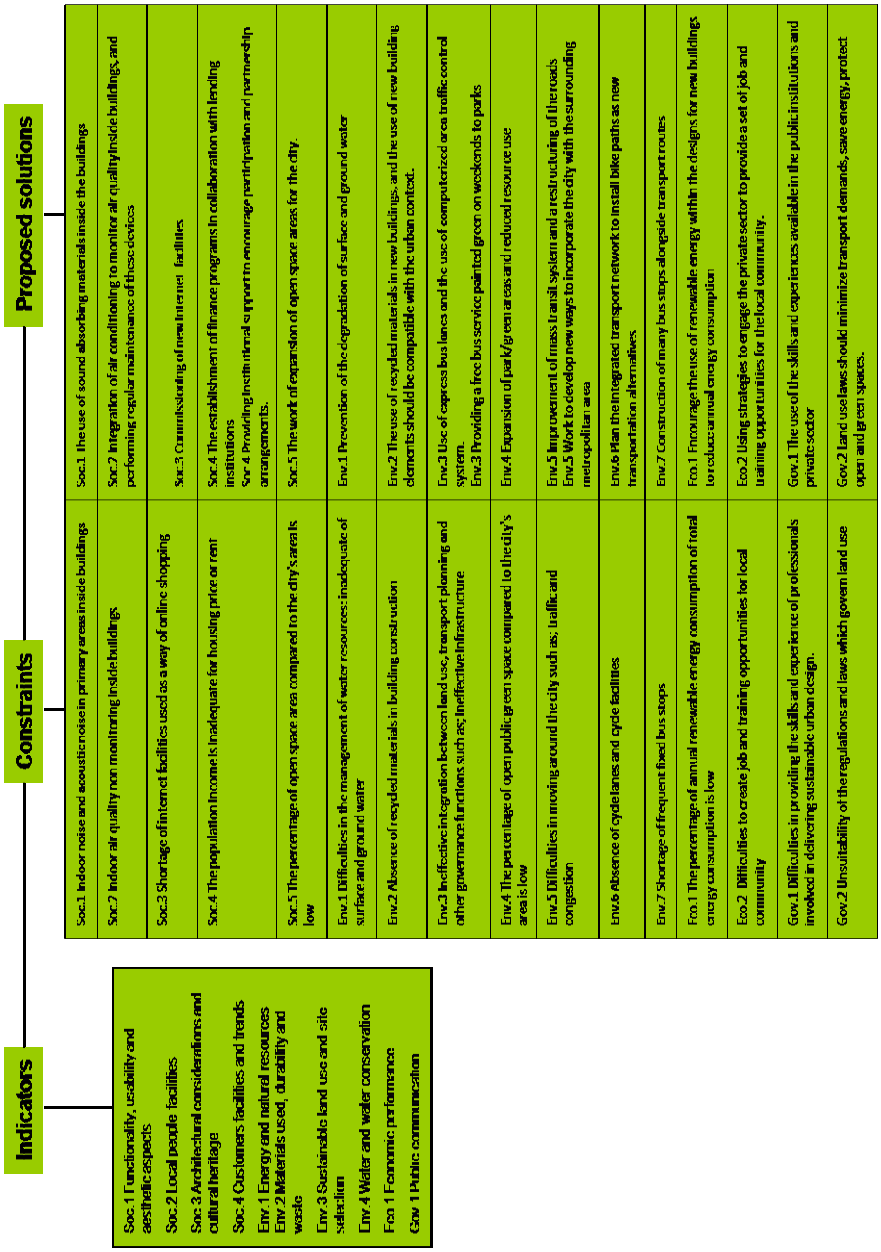

Figure. 8: First part of the summary of main findings

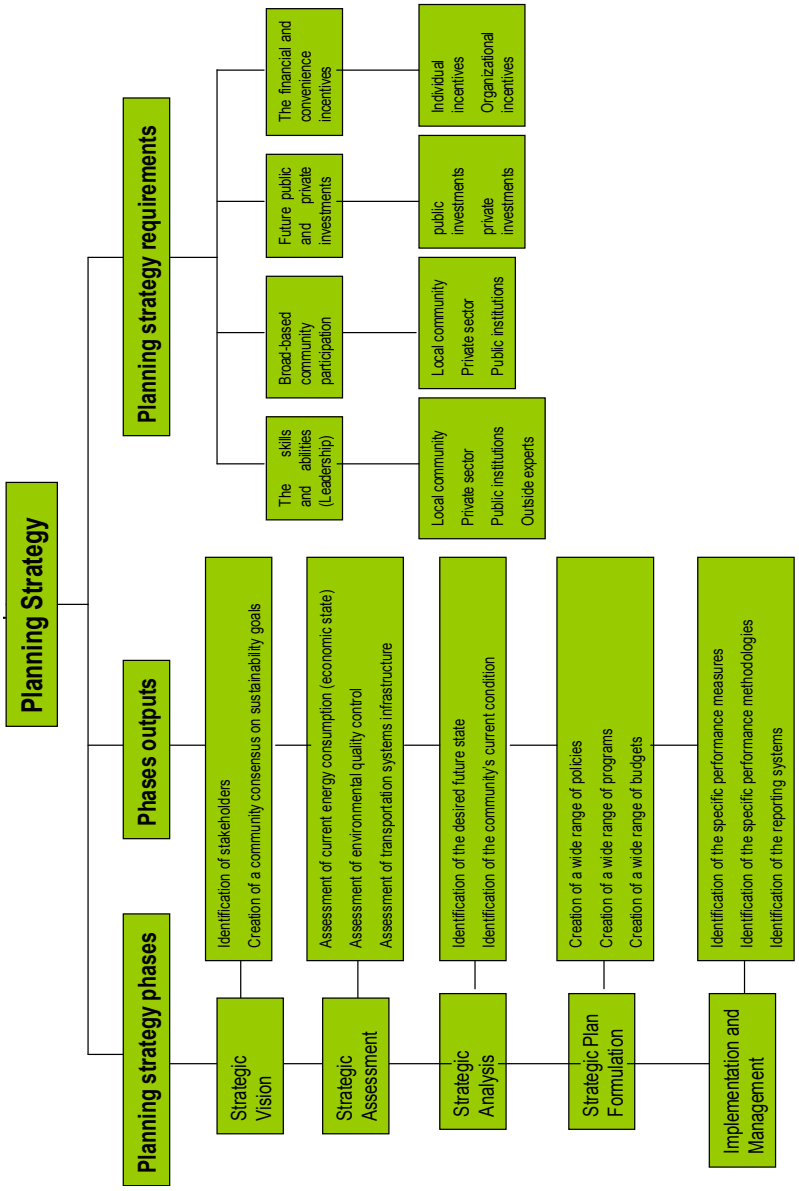

Figure. 9: Second part of the summary of main findings

7. Conclusions and Recommendations

In conclusion, the research enhanced the knowledge levels required for the implementation of sustainable urban design principles using high density mixed use. This was achieved by introducing an implementation framework focusing on the key components which constitute this framework. By exploring the underlying components that inform this framework, the thesis exposed how it can be used effectively and further fine-tuned to reflect place specific variables. In the case of Amman, the study identified the main components of the HDMU implementation framework as shown above.

The developed framework includes a series of practical recommendations that provide an opportunity to the city of Amman to inform the future development of the master plan as follows:

1. To develop the guidelines responsible for the Amman master plan according to the suitable indicators identified by this study. Moreover, to consider the ranking of these suitable indicators for the purpose of prioritising their implementation in the Amman master plan. This ranking provides useful feedback which identifies the main priorities for each indicator to overcome the constraints and fill the gaps in the implementation of the HDMU scheme. This will help to implement and manage sustainable urban design principles using high density mixed use in the Amman context.
2. To consider the main constraints that identified by this study as clarified in the Figure 8.1. These constraints can help to identify the main gaps that emerge through the implementation of the planning strategy of the sustainable urban design principles.

3. To use the proposed solutions identified by this study, in order to fill the main gaps that emerge through the implementation of this scheme. These solutions provide a means to overcome the challenges of effective implementation of the HDMU scheme. In addition, the implementation of these solutions can be used in all areas within the Amman master plan equally, using the lessons learnt in the three areas.
4. To apply the planning strategy identified by this study to achieve effective implementation of the HDMU scheme in the Amman master plan. In addition, to consider the main planning strategy phases and their outputs to be used for the HDMU scheme. For effective implementation of this process, the main planning strategy requirements are needed for this scheme.

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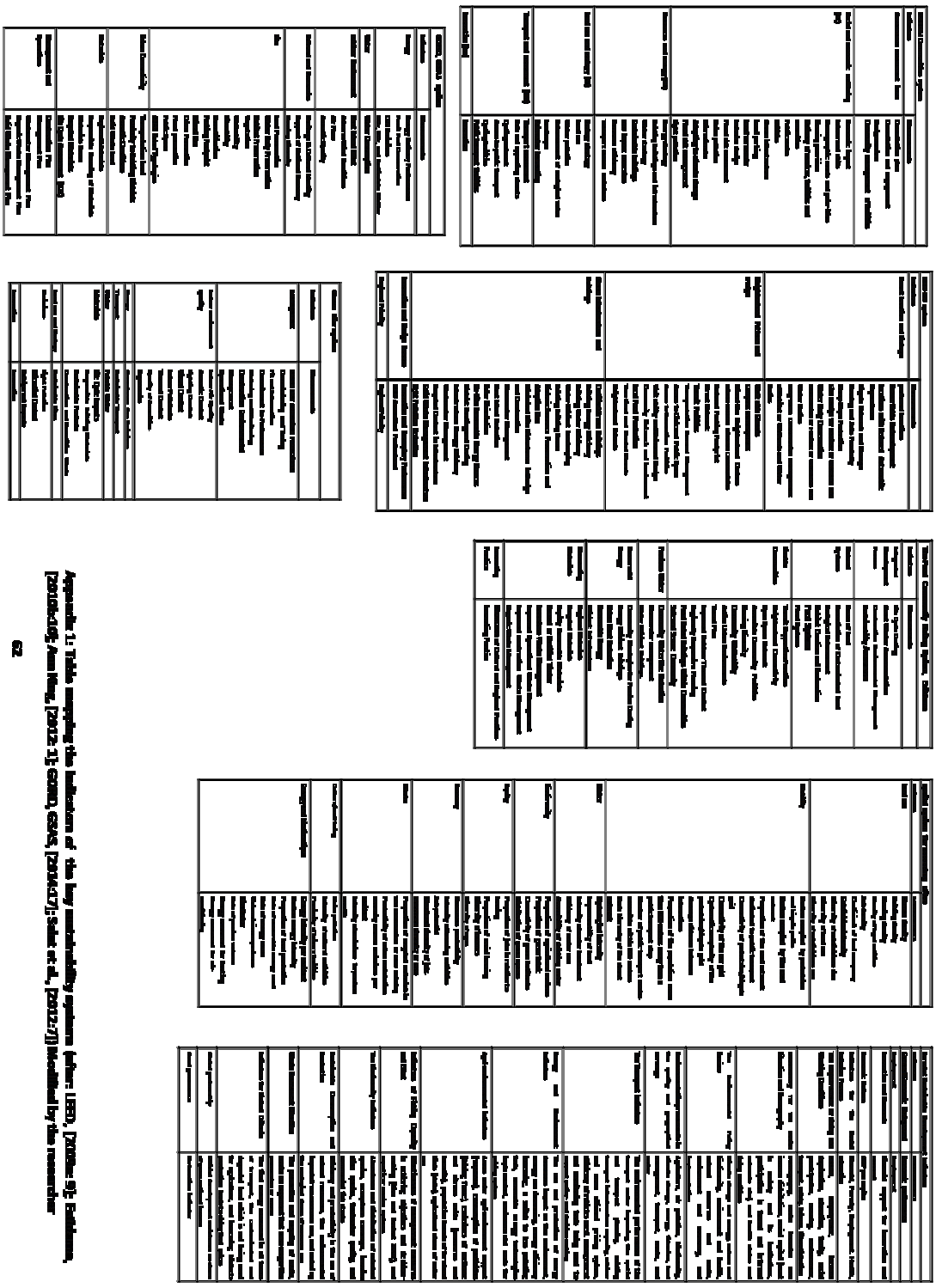
Appendix 1



Appendix 2

1. Introduction

This chapter will analysis the findings from the questionnaire survey as a means to explore key issues that relate to sustainable urban design practices, which are being undertaken in Amman, Jordan. This chapter aims to identify and evaluate the constraints, solutions, suitable urban sustainability indicators and planning strategies for the implementation of sustainable urban design principles in the Amman master plan within the selected areas (A, B, C), which represent with (A central parkway, B southern gateway, C northern gateway).

This questionnaire depends on the outcomes from testing the indicators in Amman within three case study areas as clarified in the fourth chapter. Therefore, this study will use this questionnaire to check the outcomes from comparative study areas such as; the suitable indicators, constraints and solutions for the implementation of sustainable urban design principles, using high density mixed use in Amman. In addition, the questionnaire will identify the planning strategy to mange this scheme in Amman. Hence, these factors will provide the guidelines which can be used effectively in the context of Amman. Therefore, this study will use a wide range of professionals consist of architects and planners. These professionals are sampled because they are worked in implementing the master plan either within Greater Amman Municipality or private sector. For ensuring achieving the balance for the master plan, the research will use two categories of professionals; architect and planners. The planners are responsible for creating the master plan while the architects are responsible for delivering the master plan.

The sections that follow look sequentially at the questions as they appear in the questionnaire and analysis the answers received picking up patterns and clues.

1. The constraints, solutions and suitable indicators for the Amman master plan

This section enables the researcher to test the first objective: To identify and evaluate constraints, solutions and suitable indicators for the implementation of sustainable urban design principles in Amman.

3.1 In your view, to what extent does each of the following affect the effective implementation of the sustainable urban design using high density mixed use schemes in Amman?

Table 6: Main constraints affecting the implementation of the sustainable urban design principles using HDMU

Dimension	Constraints	Highly agree	Agree	Disagree	Highly disagree	No effectiveness
Soc.1	Indoor noise and acoustic noise in primary areas inside buildings	75%	23%	1%		1%
Soc.2	Indoor air quality non monitoring inside buildings	83%	13%	2%		2%
Soc.3	Shortage of cultural facilities	88%	9%			3%
Soc.4	The population income is inadequate for housing price or rent	70%	27%	2%		1%
Soc.5	The percentage of open space area compared to the city's area is low	86%	14%			
Env.1	Difficulties in the management of water resources: inadequate of surface and ground water	74%	23%			3%
Env.2	Absence of recycled materials in building construction	95%	3%	2%		
Env.3	Ineffective integration between land use, transport planning and other governance functions such as; ineffective infrastructure	91%	7%	2%		
Env.4	The percentage of open public green space compared to the city's area is low	83%	17%			
Env.5	The percentage of waste treatment and disposal is low.	1%	8%	27%	64%	
Env.6	Difficulties in moving around the city such as; traffic and congestion	92%	6%			2%
Env.7	Absence of cycle lanes and cycle facilities	98%	2%			
Env.8	Shortage of frequent fixed bus stops	82%	18%			
Eco.1	The percentage of annual renewable energy consumption of total energy consumption is low	89%	10%			1%
Eco.2	Difficulties to create job and training opportunities for local community	71%	26%			3%
Gov.1	Emergence of Local community resistance and negative media coverage for the master plan project, because of problems in communication between private sectors and local citizens and local government bodies.		3%	19%	75%	3%
Gov.2	Difficulties in providing the skills and experience of professionals involved in delivering sustainable urban design.	19%	76%	1%		4%
Gov.3	Unsuitability of the regulations and laws which govern land use	65%	31%	2%		2%

Soc: social, Env: environmental, Eco: economic, Gov: governance.

5.3.2In your view, please specify the appropriate solutions to overcome these constraints for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman? You can choose more than one choice.

Table 7: Main constraints and their solutions affecting the implementation of the sustainable urban design principles using HDMU

Constraints	Proposed solutions
Soc.1 Indoor noise and acoustic noise in primary areas inside buildings	○ The use of sound absorbing materials inside the buildings. (98%)
Soc.2 Indoor air quality non monitoring inside buildings	○ Integration of air conditioning to monitor air quality inside buildings, and performing regular maintenance of these devices. (96%)
Soc.3 Shortage of cultural facilities	○ Commissioning of new cultural facilities. (98%)
Soc.4The population income is inadequate for housing price or rent	○ The establishment of finance programs in collaboration with lending institutions. (99%) ○ Providing institutional support to encourage participation and partnership arrangements(95%) ○ Promoting the use and maintenance of existing housing stock and the development of affordable rental housing. (1%)
Soc.5 The percentage of open space area compared to the city's area is low	○ The work of expansion of open space areas for the city. (100%)
Env.1Difficulties in the management of water resources: inadequate of surface and ground water	○ Ensuring a clean water supply for commercial, agricultural, industrial and urban uses. (3%) ○ Prevention of the degradation of surface and groundwater. (98%)
Env.2 Absence of recycled materials in building construction	○ The use of recycled materials in new buildings, and the use of new building elements should be compatible with the urban context.(99%)
Env.3Ineffective integration between land use, transport planning and other governance functions such as; ineffective infrastructure	○ Use of express bus lanes and the use of computerized area traffic control system. (97%) ○ Providing a free bus service painted green on weekends to parks. (91%) ○ Keeping the public informed about environmental issues, using programs that encourage community responsibility for the parks. Local schools promote ecological principles. (1%)
Env.4 The percentage of open public green space compared to the city's area is low	○ Expansion of park/green areas and reduced resource use. (100%)
Env.5 The percentage of waste treatment and disposal is low.	○ Using solid waste management program that encourages citizens to separate organic from inorganic. Separating piped water from sewage lines. (81%)
Env.6 Difficulties in moving around the city such as; traffic and congestion	○ The use of rapid bus transport system as a system of public transportation. (3%) ○ Improvement of mass transit system and a restructuring of the roads. (95%) ○ reducing the cost of mobility and promoting trade within the city. (2%) ○ Work to develop ways to incorporate the city with the surrounding metropolitan area. (94%)
Env.7 Absence of cycle lanes and cycle facilities	○ Plan the integrated transport network to install bike paths as new transportation alternatives
Env.8 Shortage of frequent fixed bus stops	○ Construction of many bus stops alongside transport routes. (99%)
Eco.1 The percentage of annual renewable energy consumption of total energy consumption is low Eco.2 Difficulties to create job and training	○ Encourage the use of renewable energy within the designs for new buildings to reduce annual energy consumption. (97%) ○ Using strategies to engage the private sector to provide

opportunities for local community	a set of job and training opportunities for the local community. (98%)
Gov.1Emergence of Local community resistance and negative media coverage for the master plan project, because of problems in communication between private sectors and local citizens and local government bodies.	○ Holding public debates that encourage the involvement of citizens and the private sector including architects, engineers, economists, sociologists, and public administrators. (98%) ○ Founding the regional administration centres to identify similarities between regions and plan social programs for the periphery. Integrate the public into each social programs. (97%) ○ Keeping the public informed about environmental issues, using programs encourage community responsibility for the parks, which provide aesthetic and recreational value. (1%)
Gov.2Difficulties in providing the skills and experience of professionals involved in delivering sustainable urban design. Gov.3 Unsuitability of the regulations and laws which govern land use	○ The use of the skills and experiences available in the public institutions and private sector. (100%) ○ The use of the outside experts to support this process. (2%) ○ Land use laws should minimize transport demands, save energy, protect open and green spaces.(99%)

Soc: social, Env: environmental, Eco: economic, Gov: governance.

3.3 Through the emergence of the constraints previously, do you agree or disagree with that the ranking of the suitable urban sustainability indicators for the city of Amman, which can be implemented by this process is as follows?

1. Social
2. Environmental
3. Governance
4. Economic

It is noted that professionals (architects and planners)' view on the ranking of the suitable urban sustainability indicators: 97% agree that this ranking is the suitable ranking for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman.

3.4 If you answered No in C.3 above, please rank the following to be suitable indicators for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 8: The suitable sustainable urban design indicators for Amman

Ranking	Indicators	Your ranking
1	Social	2
2	Environmental	1
3	Governance	3
4	Economic	4

Table.8 notes It is noted that professionals (architects and planners)' view on the ranking of the suitable urban sustainability indicators as below: 3% choose (1) environmental indicators (2) social indicators (3) governance indicators (4) economic indicators as suitable ranking for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman.

3.5 In your views, to what extent does each of the following are suitable indicators for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 9: Contextualised sustainable urban design indicators for Amman

Dimensions	Indicators	Highly agree	Agree	Neither agree nor disagree	Disagree	Highly disagree
Social	Functionality, usability and aesthetic aspects	90%	10%			
	Local people facilities	86%	13%	1%		
	Architectural considerations and cultural heritage	85%	14%		1%	
	Customers facilities and trends	89%	8%		3%	
Environmental	Energy and natural resources	92%	8%			
	Materials used, durability and waste	77%	21%	2%		
	Sustainable land use and site selection	89%	11%			
	Water and water conservation	81%	17%	2%		
Economic	Economic performance	76%	22%	2%		
Governance	Public communication	91%	8%		1%	

2. The planning strategy

This section enables the researcher to test the second objective: To explore the planning strategy for the implementation of sustainable urban design principles.

4.1In your view, please specify which of the planning strategy phases following can be used for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman? You can choose more than one choice.

Table 10: The main outputs for the planning strategy phases

planning strategy phases	percentage
Strategic Vision	100%
Strategic Assessment	99%
Strategic Analysis	98%
Tactical Alternatives	5%
Strategic Plan Formulation	100%
Implementation and Management	100%

4.2 In your opinion, to what extent does each of the outputs following can be used for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 11: The main outputs for the planning strategy phases

Phases	Out puts	Highly agree	Agree	Disagree	Highly disagree	No effectiveness
Strategic vision	Identification of stakeholders	83%	15%			2%
	Creation of a community consensus on sustainability goals	80%	17%	2%		1%
Strategic assessment	Assessment of current energy consumption (economic state)	91%	8%			1%
	Assessment of environmental quality control	94%	4%			2%
	Assessment of transportation systems infrastructure	89%	8%	1%		2%
Strategic analysis	Identification of the desired future state	95%	2%	1%		2%
	Identification of the community's current condition	87%	7%	2%		4%
Tactical alternatives	Political tactics	14%	82%	2%		2%
	Economic tactics		2%	21%	76%	1%
	Social tactics			26%	72%	2%
	Environmental system technologies tactics		1%	14%	83%	2%
Strategic Plan formulation	Creation of a wide range of policies	91%	7%	1%		1%
	Creation of a wide range of programs	95%	5%			
	Creation of a wide range of budgets	88%	11%			1%
	Creation of a wide range of deployment schedules		1%	18%	78%	3%
Implementation and management	Identification of the specific performance measures	87%	11%			2%
	Identification of the specific performance methodologies	90%	10%			
	Identification of the reporting systems	76%	21%			3%
	Identification of the progress adjustments		1%	20%	78%	1%

4.3 In your view, please specify which of the planning strategy requirements following can be used for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman? You can choose more than one choice.

Table 12: Main planning strategy requirements for the implementation of sustainable urban design

planning strategy requirements	ratio
The skills and abilities (Leadership)	100%
Broad-based community participation	98%
Consensus of views	4%
Future public and private investments.	99%
The financial and convenience incentives	97%

4.4 In your views, to what extent does each of the following affect the effective implementation of the sustainable urban design using high density mixed use schemes in Amman?

Table 13: Main planning strategy requirements for the implementation of sustainable urban design

Requirements	Positive effect	No effect	Negative effect	Do not know
Competencies and skills (Leadership)	99%	1%		
Broad-based community participation	97%	2%		1%
Consensus of views	5%	81%	10%	4%
Future public and private investments.	98%	2%		
The financial and convenience incentives	97%	1%		2%

4.5 In your view, please specify the competencies and skills needed to each phase for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 14: Competencies and skills for the implementation of sustainable urban design

Competencies and skills	Study of project	Preparation of plans	Design of plans	Implementation of project	Monitoring of project
Local community	95%	1%			96%
Private sector	99%	2%	2%	100%	
Public institutions	100%	100%	99%	1%	98%
Outside experts	98%	97%	99%		2%

4.6 In your opinion, to what extent does each of the following can be used as competencies and skills for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 15: Competencies and skills for the implementation of sustainable urban design

Competencies and skills	Highly agree	Agree	Neither agree nor disagree	Disagree	Highly disagree
Local community	84%	13%	2%	1%	
Private sector	91%	8%	1%		
Public institutions	98%	2%			
Outside experts	88%	9%	2%	1%	

4.7 In your opinion, to what extent does each of the following affect the planning strategy for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 16: Community participation for the implementation of sustainable urban design

Community participation	Highly agree	Agree	Disagree	Highly disagree	No effectiveness
Local citizens	81%	16%	1%		2%
Private sector	92%	7%			1%
Public institutions	97%	3%			

4.8 In your view, please specify which of the methods following can be used to provide the technical and administrative support for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman? You can choose more than one choice.

Table 17: Community participation for the implementation of sustainable urban design

Community participation	Interviews	Focus group	Survey
Local citizens	1%	3%	98%
Private sector	2%	96%	99%
Public institutions	97%	96%	5%

5.4.9 In your opinion, to what extent does each of the following affect the planning strategy for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 18: Consensus of views for the implementation of sustainable urban design

Consensus of views	Highly agree	Agree	Disagree	Highly disagree	No effectiveness
Local citizens	82%	14%	1%		3%
Private sector		1%	7%	89%	3%
Public institutions	94%	4%	1%		1%

5.4.10In your opinion, to what extent does each of the following affect the planning strategy for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 19: Investments for the implementation of sustainable urban design

Investments	Highly agree	Agree	Disagree	Highly disagree	No effectiveness
public investments	91%	7%			2%
private investments	97%	3%			1%

*5.4.*11 In your opinion, to what extent does each of the following affect the planning strategy for the effective implementation of the sustainable urban design principles using high density mixed use schemes in Amman?

Table 20: Incentives for the implementation of sustainable urban design

Incentives	Highly agree	Agree	Disagree	Highly disagree	No effectiveness
Individual incentives	91%	5%	1%		3%
Organizational incentives	80%	17%			3%